
PHILOSOPHICAL
TRANSACTIONS.

- I. *On the Nature of the Gorgonia; that it is a real Marine Animal, and not of a mixed Nature, between Animal and Vegetable. By John Ellis, Esq. F. R. S. in a Letter to Daniel Solander, M. D. F. R. S.*

MY DEAR FRIEND,

R. June 29, 1775. **I**T was your particular request, before you went to the South Seas, that I should continue my researches into the formation and growth of *Zoophytes*, more particularly of those formerly called *Ceratoephytons*, now *Gorgoniæ*; and known in English by the name of sea-fans, sea-feathers, and sea-whips, to which class the red coral should be added. This you thought the more necessary, as the accounts already published of them by the illustrious Dr. LINNÆUS and Dr. PALLAS seemed to make them of a mixed nature in their growth, between animals and vegetables: a thing not easily to be reconciled to the usual operations of nature.

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I was

I was so fortunate about that time to receive from my right honourable friend the earl of HILLSBOROUGH, a most excellent collection of different species of these animals preserved at the sea-side in spirits, by JOHN GREG, esq. F. R. S. of Dominica. This hath enabled me to shew more clearly, that they are true animals, growing up in a branched form, and in no part vegetable.

From the following observations it will appear, that the *gorgonia* is an animal of the *polype* kind, resembling the common fresh water *polype* in many of its qualities, but differing from it in the remarkable circumstance, of producing from its own substance a hard and solid support, serving many of the purposes of the bone in other animals. Every one knows, that the common *polype* sends out its young from its side, like buds, which being grown to the form of the parent animal, to which they still adhere, send out again their own young, like buds, adhering to themselves; and this is repeated, till at length the whole acquires a branched appearance, resembling a vegetable, see fig. 1.

The *gorgonia* grows nearly in the same manner; and hence arises its resemblance to a shrub, which hath given occasion to the mistake of placing it in the vegetable kingdom. But though the nature of these animals is so much like the *polypes*, they differ in several circumstances; the most remarkable is that which I have already mentioned, the hard bone by which the *gorgonia* is supported. This is not formed by any kind of vegetation, but by a concreting juice thrown out from a peculiar set of longitudinal

tudinal parallel tubes, running along the internal surface of the fleshy part. In the coats of these tubes are a number of small orifices, through which the *offeous* liquor (if I may use the expression) exudes; and concreting, forms the layers of that hard part of the annular circles, which some, judging from the consistence rather than the texture, have erroneously denominated wood.

Dr. PALLAS, in his *Elench. Zoophytorum*, p. 162. is of opinion, that the layers of which the wood, as he calls it, of the tougher *gorgoniæ* is composed, may be separated into numerous longitudinal fibres; that the longitudinal *striæ*, which frequently appear on its external surface, are owing to this structure; and that these fibres are in fact hollow, like the wood of trees, the cavity of the tubes being closed up, as they become hard and rigid.

I was nearly of the same opinion when I was writing my *Essay on Corallines*, as may be seen in the Philosophical Transactions. vol. XLVIII. p. 18. and also p. 504. t. 17. where I have compared the herring-bone coralline, which is composed of many little tubes, to the growth of sea-fans and sea-feathers, now called *gorgoniæ*; and likewise in my *Observations on the Growth of the red and white Coral*, see Philosophical Transactions, vol. XLVIII. p. 504. t. 17.; but experience has since fully convinced me of the contrary: for upon the strictest examination with the microscope, of the internal horny parts of several of those *gorgoniæ* fresh from the sea, and immediately preserved in spirits, not the least appearance of tubes within the horny part can be discerned, either in the longitudinal or transverse sections. There

is indeed a regular cannulated appearance on the surface; but this seems to be only an external moulding, and not formed by a series of longitudinal tubes with interstices, as in plants; nor is it difficult to explain from whence such a moulding may arise. I have observed, that the inner surface of the fleshy part contiguous to the bony or horny part, is furnished with longitudinal parallel tubes, which through certain pores supply the *osseous* matter; this being soft at first, and only afterwards becoming hard, so as necessarily to take the form of the concave surface by which it is closely pressed, and therefore assumes a striated appearance. This is plainly seen in fig. 2. A. where the ends of the tubes and the striated appearance on the *gorgonia flabellum* are expressed; and at fig. 2. B. two of them are magnified.

In the *Isis bippuris*, or black and white jointed coral, which is very nearly a-kin to this *genus*, these tubes are still more clearly to be seen, as they are larger and the channels much deeper, see fig. 3. where A is a part of the coral of its natural size; B is an extremity of one of the branches magnified, with the bony part laid bare; C a part of the same, with the bony part taken out, to shew the tubes with their internal orifices, through which the *osseous* juice is supposed to exude, and form the layers of the bony and horny part. This formation of the hard part or bone of the stem seems to be a principal use of the longitudinal tubes; but they have another also, of great consequence in the growth of the *gorgonia*: for it is by means of these, that the animal spreads itself downwards over the substances which serve for its basis, thence
deriving

deriving a firmness proportioned to its bulk. By means of these likewise, it repairs any deficiencies arising either from accident or natural decay, by which the life of the whole would be endangered. At fig. 2. c, d, the broken stem in the *gorgonia flabellum* is strengthened and made firm by the lateral reticulations being covered over with the horny substance by means of these fleshy tubes and *polype* suckers. This is very different from any natural repairs of broken or wounded branches in trees. Besides, these tubes extend themselves any way, creeping over every substance which may serve for their support and preservation of the animal, throwing out the horny or *osseous* juice to make the whole texture firmer. This wonderful contrivance of nature is certainly instinct in this low order of animals. To give a better idea of this kind of instinct, and to shew in what it differs from what is called radication in plants, with which some people, for want of better information, are apt to confound it, I have given a figure of the manner in which the *fußra foliacea* fastens itself to shells, see fig. 4. This figure is a little magnified, to shew the form of the cells, as they have spread themselves over the surface of the scollop shell. The advocates for the vegetation of *zoophytes*, I hope, will be convinced, that the part that sticks to the shell is not a root, but only a single course or layer of cells of the same animal. As it rises into leaf-like branches they become double, or two layers of cells, placed in such an opposition to one another as to strengthen the whole, like the cells in the honey-comb; and what is very singular, the narrow part of the stem near the shell, often

consists of four or more layers of cells, which the animal, by this kind of instinct, most certainly applies to strengthen that slender part against the force of the waves. For another instance of the base of a *zoophyte* spreading downwards to secure itself, we have an example in the *madrepora muricata*, which is extending itself over a dead animal of the same species, see fig. 5.

The following remark of Dr. PALLAS will shew, that as he conceives the wood or horny stem to be composed of tubes, so he thinks that there is a communication of juices from the *polypiferous* pores on the cortical part to the inside or horny part, as in trees: for he observes, that as the trunk of the *gorgonia* is always proportioned to the size of its branches, the wood or horny part of the trunk, notwithstanding its hardness, must necessarily thrive, grow and increase every way, even though the organs of the bark, or surrounding fleshy substance, at the trunk and base are obliterated^(a); and hence he concludes, that the trunk must receive nourishment from the branches, and apprehends, this nourishment to be absorbed and prepared by *polypiferous* pores. Now it is evident, that the idea of the trunk and base of a tree growing in thickness, when it is divested of its surrounding bark, is contrary to the known laws of vegetation. The only method of increase in the trunks of trees is by

(a) Semper baseos amplitudo et imi trunci crassities proportionata magnitudini fruticis reperitur; argumento corneam eorum partem, quam exemplo arborum fruticumque, lignum dicere queat, obstante duritie ubique vigere, vivere et in omnem dimensionem crescere, obsoletis quamvis corticis in trunco et basi organis. PALLAS, Elench. Zoophyt. p. 161.

the apposition of new layers from the bark, which cannot be produced but while the bark is subsisting.

Nor can the *gorgonia* increase in size, in those parts where it is deprived either of the flesh with the *polype* suckers, or the surrounding fleshy tubes, which communicate with these suckers; for these suckers and tubes are the organs that prepare and deposit the several thin layers, which form the support or bony part (here called wood), as I have shewn before. If upon examining the internal structure of these *zoophytes* it were found, that their growth and fabric any ways resembled that of vegetables, this would indeed afford a presumptive argument, that they did participate of a vegetable nature. Yet even in that case, it would be much more reasonable to suppose them animals of the lowest order, raised but one degree above the vegetable tribe, than to conjecture a monstrous metamorphosis repugnant to the general analogy of nature. But the truth is, that although the hard parts of many *gorgoniæ* have very much the external appearance of wood, yet the internal structure differs in the most essential points from vegetables.

In order to prove this, I have compared different sections of the *gorgonia* with correspondent sections both of sea and land plants, and find they differ in the following particulars: The longitudinal sections of the stems of the larger *fuci*, such as the *fucus digitatus*, *esculentus*, *nodosus*, and *saccharinus*, appear composed of parallel jointed tube-like figures, the joints of which are composed of gland-like cells; these tubular appearances, when highly magnified, are discovered to be connected
together

together by transparent reticulated fibres, or very minute transverse tubes, interwoven with the upright ones. In a horizontal section, the ranges of cells, which look like rays from the center, as they approach the bark, grow smaller and smaller, and most probably correspond with the minute pores which cover the outward surface of the plant; for when the sides of the dry stems are soaked in water, they quickly imbibe it, and soon become full of a gelatinous liquor; all which is totally different from the texture of the *gorgonia*.

We come now to compare them with land plants, such as shrubs, to which they are generally supposed to grow like. The *gorgonia* has no regular series of hollow fibres or little tubes, in what is called the wood, either longitudinal or horizontal. It appears composed of a sort of irregular *laminae* like horn; the fibres of which take no certain direction, nor preserve in any two places the same thickness. It has no series of utricular vessels, as the transverse vessels of wood are called by MALPIGHI; or insertions as they are called by Dr. GREW. These are essentially necessary, as forming a communication from the bark and the internal parts of the wood quite through. On the contrary, the concentric circles of the *gorgonia* have no connexion with each other; they run like so many parallel curves, and are connected by no insertions or utricular vessels; but to all have been appearance formed by separate depositions of concreting matter. So the shells of snails and oysters are formed; their respective animals throw out periodically the *osseous* juice or *testaceous* matter, which adheres to the former shell and concretes, and
thus

Fig. 2.

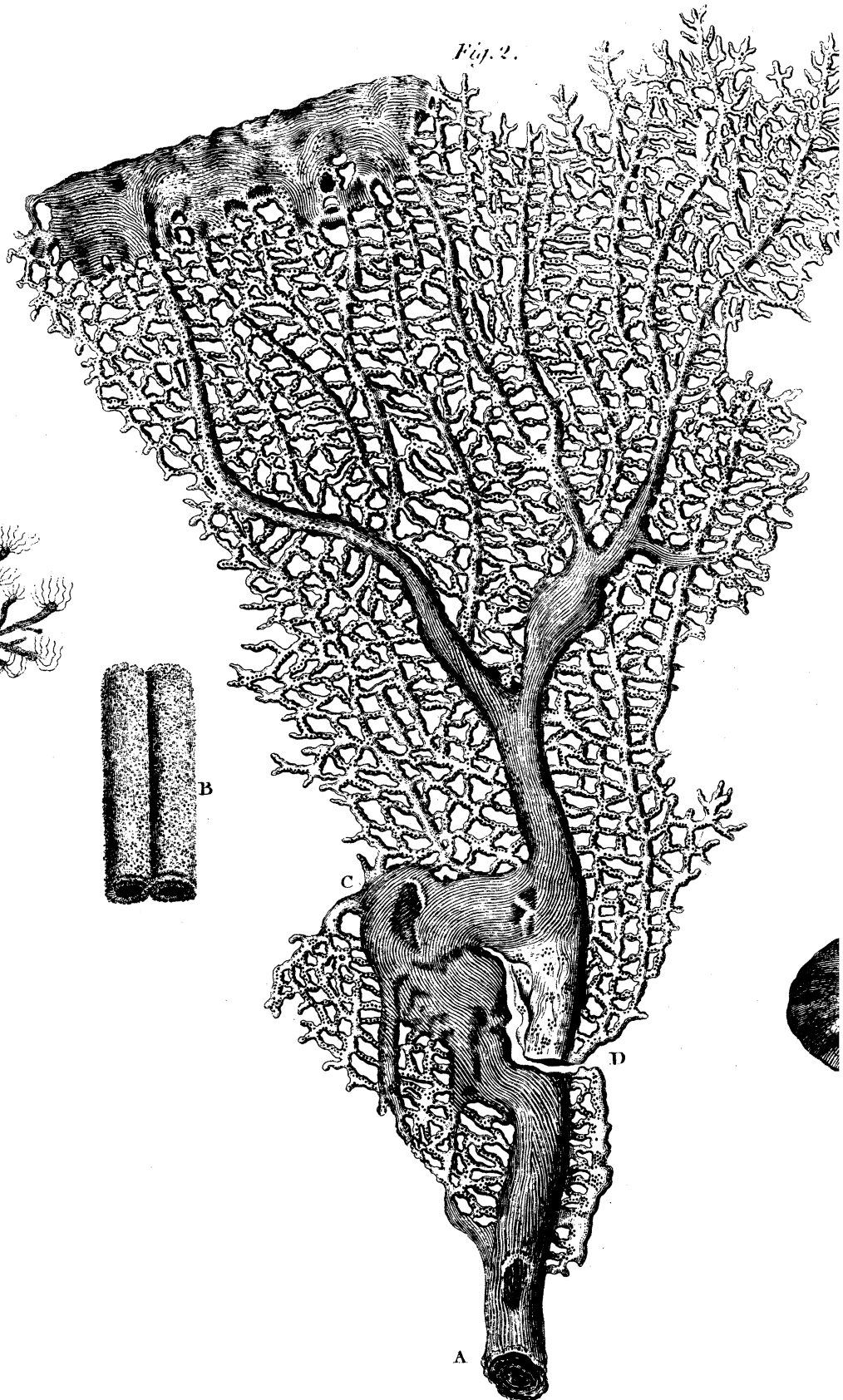
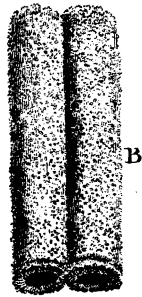
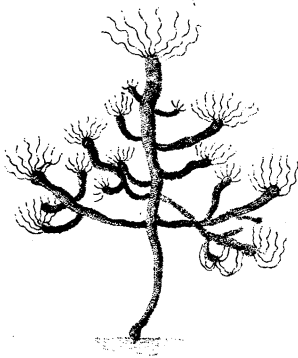


Fig. 1.



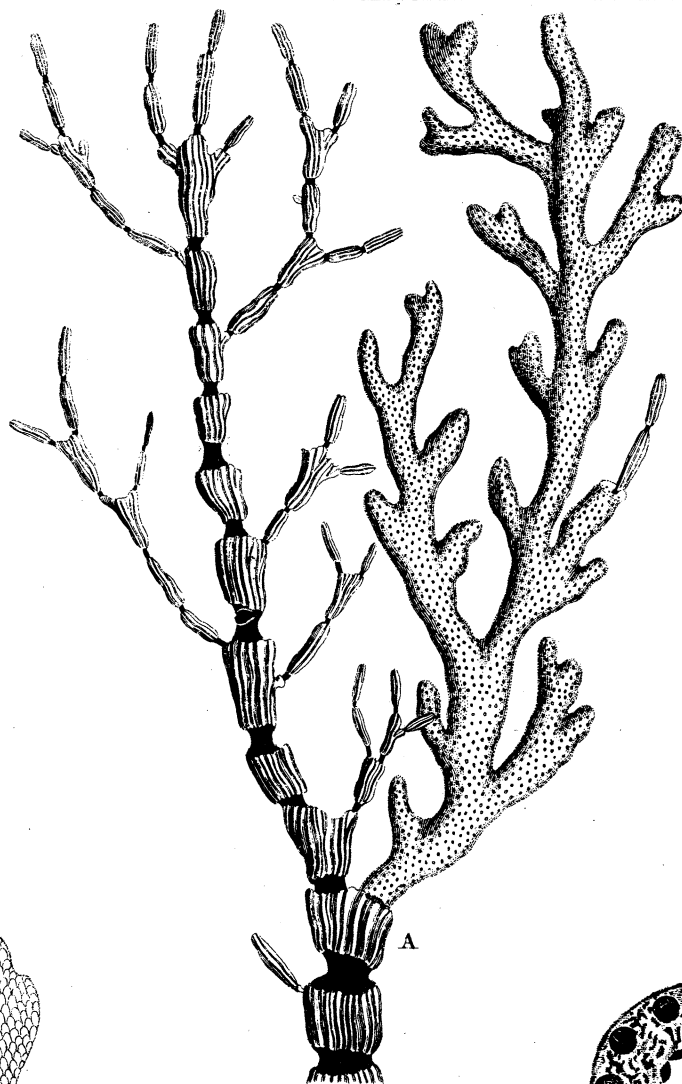
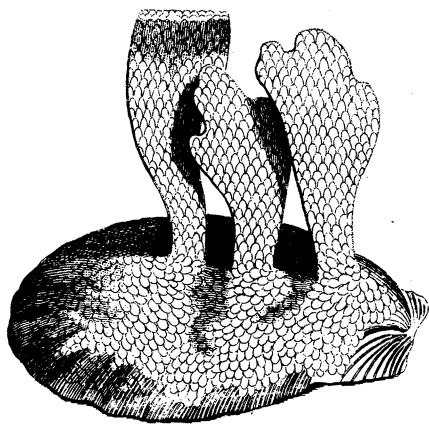
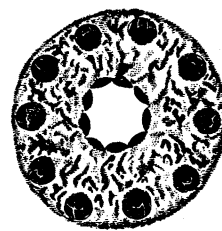


Fig. 3.

Fig. 4.



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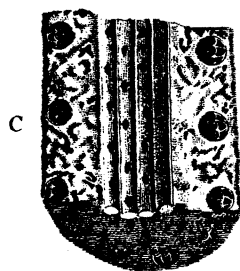
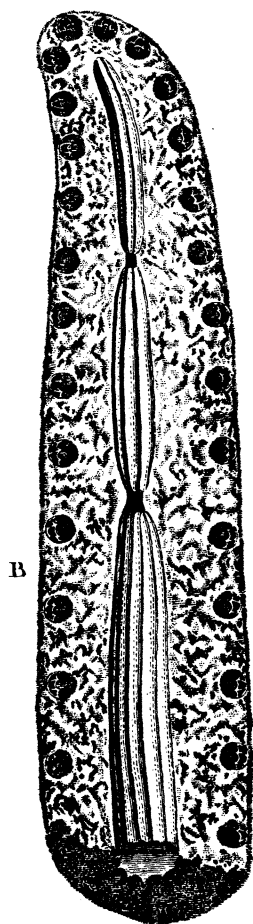
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B



C





thus successive layers are produced. In the same manner I suppose the concentric circles of the *gorgonia* to be formed, successive layers of juice exuding from the fleshy tubes that surround the hard part or bone of the animal. Thus the stem of the *gorgonia verticillata*, or *Minorca white sea-feather*, is composed of different layers of a shell-like substance (see fig. 6.), where a broken part of the stem is represented, and a piece of it magnified, to shew that there is evidently no more communication between the different *laminæ* than there is between those of an oyster-shell. In a transverse section of the *gorgonia pretiosa*, or true red coral, DONATI has observed, Philosophical Transactions, vol. XLVII. p. 97. t. 3. f. d. “ Different lines or annual bands, whereof one part is of “ a rose colour, another yellowish, others white, others “ more or less charged with colours, that form concentric circles like the coats of an onion.” This diversity of colours could hardly have taken place, had there been a circulation of juices through the stem; and it was probably owing to the different food which the animals had lived upon at different periods.

There is another *genus* of *zoophyte*, which though it swims freely about in the sea, yet approaches near to the *gorgonia*, and will serve further to explain the growth of its stem, and that is the *pennatula*, or sea-pen. This *genus* hath a bone along the middle of the inside, which is its chief support. This bone receives the supply of its *osseous* matter by the same *polype* mouths, that furnish it

with nourishment. Dr. BOHADSCH has very judiciously brought to this *genus* the great Greenland clustered *polype* formerly described by me under that name, and now called *pennatula arctica*. In a cross section of the bone, see Philosophical Transactions, vol. XLVIII. tab. XII. F. H. the several *laminae* are magnified, to shew that they are formed in layers like shells, and are not full of tubes as in a vegetable growth. These animals are ranged among the vegetating kind, and so called by Dr. PALLAS. There is a great affinity between the *gorgonia* and *isis*, so that the increase of the bone of the latter will greatly illustrate that of the former. The longitudinal section of the bone to the stem of the *isis bipurpuris* will shew, that it hath been increased in diameter by successive layers of stony matter that surround it, see fig. 7. In this instance we can trace the bone in its infant state, when nature had given it pliable black horny joints, that it might yield the better to the violence of the waves; but as soon as it became stronger, these horny black joints were no longer necessary, as we find the lower part of the stems totally overgrown with the bony substance. The furrows in this coral are deeper than those of any other; insomuch that not only the longitudinal fleshy tubes that surround the bone, but even the minute pores in them, through which the *osseous* juice exudes, are very discernible see fig. 3.

We now come to a very singular circumstance in the growth of the *gorgonia*, in which it differs remarkably from that of trees. In fig. 8. is the figure of the naked stem

stem or bone of a *gorgonia*, to which we find several tree oysters and other shells have adhered. These shell-fish seem to have killed the *gorgonia*; for the same stem seems to be covered over with another *gorgonia* of the same kind; which in its growth hath almost covered the shells, and likewise the branches to which they were fastened, leaving only part of the ends of the branches of the first *gorgonia* yet uncovered. The size and weight of the shells probably gave the waves so great a power over the stem, that it was at last broken off, and cast on shore in the state in which it is here represented. This instance of a *gorgonia* growing over one of its own kind, seems sufficient to account for the circle of calcareous matter found now and then in the cross sections of old stems, between the horny circles, as hath been observed by Dr. PALLAS, Elench. Zooph. p. 162. “Interjecto quandoque “tenui materiæ calcareæ strato.” But, I believe, no one hath ever seen the bark of trees inclosed in the same manner in the inner circles of the wood; and indeed it is so contrary to the laws of vegetation, that Dr. PALLAS hath not attempted to account for it, by shewing any parallel instances in the transverse sections of timber. Another instance of the manner of growing of these animals is still more remarkable, see fig. 2. where the upper part of the *gorgonia flabellum* meeting with an obstruction in growing upwards, has grown downwards over its own fleshy substance, and has evidently inclosed and covered over its own reticulated branches, with a continuation of its own flesh and bone. Dr. PALLAS, in a note on the growth of the *gorgonia*, hath the following extraor-

dinary observation, that a gentleman in Holland is possessed of a *gorgonia*, which has on the same shrub, the bark partly of a *gorgonia verrucosa*, and partly of the *gorgonia coralloides*, without any visible difference of the branches; which he accounts for by comparing it to the growth of vegetables, saying: “ So different *lichens* are
 “ often found incorporated in such a manner together,
 “ that they might easily be mistaken for one and the same
 “ plant^(b). But I think it rather paradoxical to suppose the flesh of one animal to grow on the bones of another. If he had examined it attentively, he would have found what we have advanced to be the case. It is not unusual for a *gorgonia* of one species to grow upon the decayed branches of an individual of another, where the soft or fleshy part is already perished; but the upper or living *gorgonia* must have its own hard as well as soft parts; for should there be the fleshy part, and not the bony part, it would belong to the *genus* of *alcyonium*, and occasion such another remarkable mistake as this author has already made in his *sertularia gorgonia*, see Elench. Zooph. p. 188. where he has described an *alcyonium*, growing upon and surrounding the stem and part of the branches of the *sertularia frutescens*, as a new species of *sertularia*. This, he says, most closely unites the *genus* of *gorgonia* with that of the *sertularia*: and to convince me of the

(b) Quod in eodem frutice corticem partim gorgoniæ verrucosæ partim coralloides exhibet, sine ullo visibili discrimine ramorum. Verum et diversæ sæpe lichenes ita sibi invicem inoliti reperiuntur, ut pro unâ facile plantâ sumeres. PALLAS, Elench. Zooph. p. 163.

truth of what he asserts, he has sent me part of the original specimen, of which fig. 9. exhibits an exact representation. At A is a magnified figure of this *alcyonium*, on a piece of the branch of the *fertularia*. It is of a fleshy substance with warts, having each twelve rays; we have many species of *alcyonia* from the West Indies not much unlike this. The reader, by attending to the Doctor's own description of his *fertularia gorgonia*, will soon be convinced of the error, especially when he considers, that the character of a *fertularia* is that of a branched animal, with the hard parts without, and the fleshy parts within; and that the *gorgonia*, on the contrary, hath its fleshy or soft parts without, and its bone or hard parts within.

There is another essential difference hitherto unnoticed, between the growth of the *gorgonia* and that of trees; and that is, in the connexion between the side branches and stem of the one, and the side branches and stem of the other. The side branches of vegetables proceed from the pith; of course, when a stem and side branch is divided length ways, the pith is seen continued through the main stem into the branch, see fig. 10. where A. is the natural size of a small twig of the lime tree, and B. the same magnified. It must be observed, that in some trees the channel or continuation of the pith which leads from the stem to the side branch, is very much contracted, and the communication very narrow; in which case it will be necessary to make cross sections, which will soon discover the course of the pith
from

from one to another. M. DU HAMEL, an author of the first reputation, hath clearly demonstrated this in his *Physique des Arbres*, vol. II. p. 119. tab. II. f. 91. Now in the *gorgonia*, the support, or what is called the woody part, is indeed furnished with a kind of a pith or *medulla*: but when we cut the stem or branch through the middle lengthwise, we find no passage whatsoever between the pith of the stem and that of the branch, each being surrounded with a hard covering of its own, which hath no perforation, nor admits of any communication. Every branch of a *gorgonia* therefore hath its own pith or *medulla* peculiar to itself, which is never found passing into that of another, see fig. 11. A. the natural size, B. magnified. Again, in trees, the pith is largest in young shoots, and disappears in old stems: in the *gorgonia* the *medulla* is of the same diameter in the old stems as in the young branches. In the longitudinal sections of fresh shoots of trees, the pith in the microscope looks like a number of jointed tubes united together; and in the cross sections, it appears like so many circles. In dried specimens the tubular appearance in the longitudinal sections is more irregular; they look rather like longitudinal ranges of little transparent blebs, and the cross sections appear like circles intersecting one another in the margin; but there are many varieties of figures in the pith of different vegetables; what is mentioned here, is the common appearance of pith in most plants. When we cut a dry branch and stem of a *gorgonia* through the middle lengthwise, the pith appears divided into many little transverse membranes, like small

white *diaphragms*, separated from one another about the distance of their own diameter. But these cross membranes are found to be more numerous in such as have been preserved directly from the sea in spirits; and when they are examined in the microscope, they appear to be of the nature and substance with the *laminae* that compose the horny tube that surround them^(c).

(c) While I was comparing the longitudinal sections of the young branches of trees with those of the *gorgonia*, I was surprized to find such a similitude between the pith of a branch of a walnut tree, of a year's growth, and that of the *gorgonia*, see GREW, *Anat. of Plants*, tab. xix. fig. 4. A. and B.; especially as we are told by a modern author, who hath published many microscopical observations on the construction of timber, that the cell-like divisions in the branch of a walnut tree are only a row of single blebs of pith. But the microscope discovers to us, on viewing one of these cross membranes, that it is composed of many cells shrunk up and united together; for, upon viewing the flat surface of one of them, it appeared full of circles intersecting one another, like a thick transverse section of many other dried piths pressed together: besides, the thicker part of this shrunk-up walnut pith, all round next the inside close to the wood, when magnified, plainly shewed the same appearance of blebs as in other pith. To confirm this observation, May 23, 1772, I procured a young green shoot of a walnut tree, growing from a branch of the preceding year; and examining the pith, both in upright and transverse sections of this new shoot, I found that they exactly resembled the pith of many other trees, but were full of sap: and that the ranges of cells or blebs that occupied one of these spaces could not be less than a hundred, perhaps double that number of blebs. Dr. GREW takes notice, p. 120. in his *Anatomy of Plants*, that there are other trees beside the walnut tree whose pith in the last year's shoot shrinks up and forms such cavities; and an ingenious friend of mine, now engaged in an enquiry into the structure of plants, hath shewn me a last year's stem of the *brassica sylvestris*, or shrubby cabbage, whose pith is shrunk and divided into a single row of cells, like those of the walnut tree of last year's growth.

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I come now to the outside covering or skin of the animal. As few have been at the pains to examine the surface of the *gorgonia* accurately, it hath scarcely yet been noticed, that they are cloathed with a kind of scales, and some of them so remarkably covered, and the scales so well adapted to the particular parts, that one might reasonably be induced to think, that nature hath given them this defence, as she hath done in like manner to the several parts of snakes and lizards, as a kind of armour to protect them from external injuries. As instances of the above, I shall only mention, that the surface of the stem as well as the mouth of the cells of the *gorgonia placomus* are defended by long pointed scales, see *Essay on Corallines*, p. 27. t. A. 1. to 3.; and the *gorgonia verticillata* (of which an elegant specimen is to be seen in the British Museum) hath also very remarkable scales of different sizes round the mouths and on the skin, see *Essay of Corallines*, t. 26. f. s. 1. The *gorgonia lepadifera* hath a most remarkable variety, placed like tiles, one over another, for the defence of the mouth of the cells that inclose the *polype* suckers; besides, there is a small kind of scales, that covers the surface of the stem and branches, see fig. 12.

From the skin we are naturally led to speak of the flesh of the *gorgonia*, or what the modern naturalists call the bark or *cortex*. Whoever hath examined the flesh of the *gorgonia*, well preserved at the sea-side in spirits, will find, on dissecting them, proper muscles and tendons for extending the openings of their cells; for sending forth

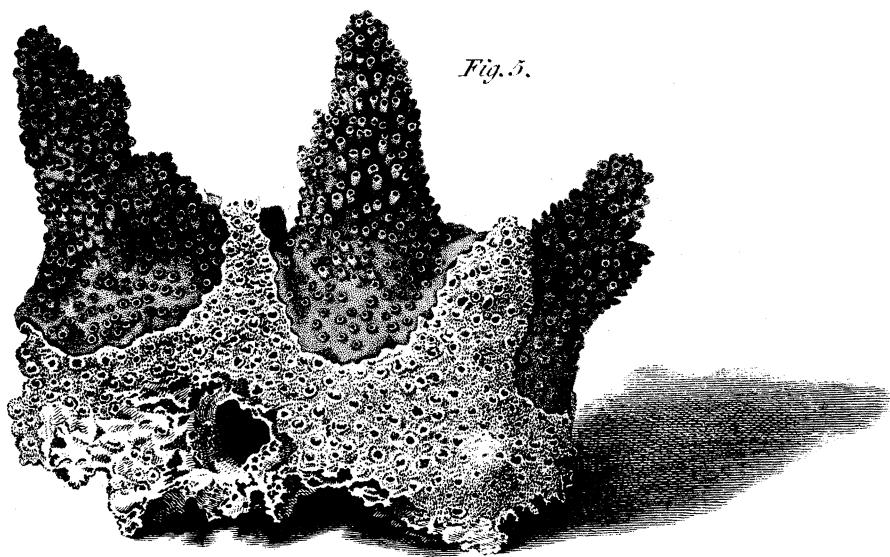


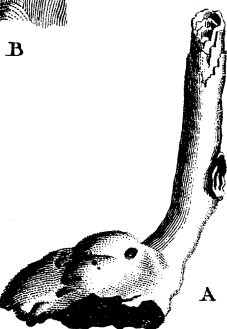
Fig. 5.



Fig. 8.



Fig. 6.



A



B

Fig. 7.

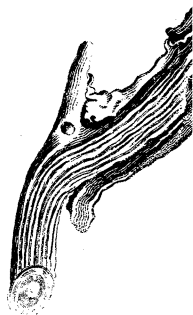




Fig. 8.

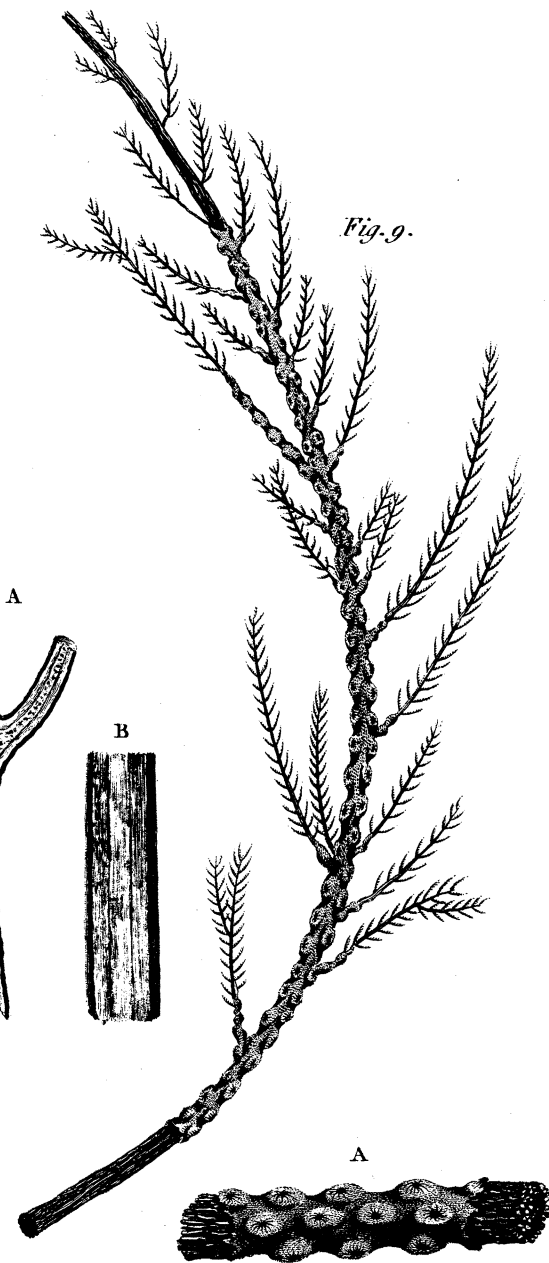
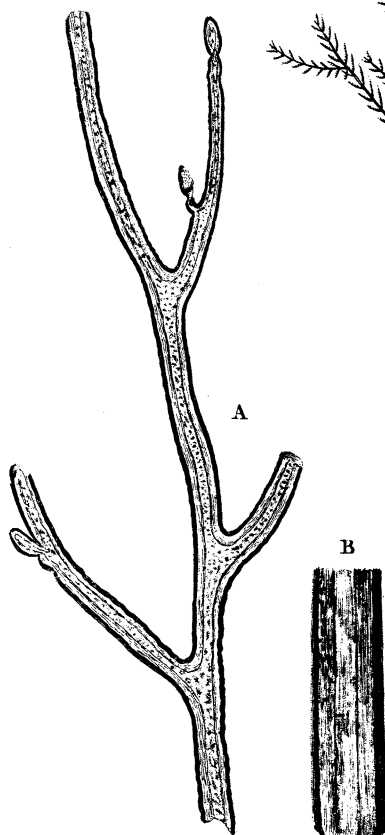


Fig. 9.



Fig. 12.

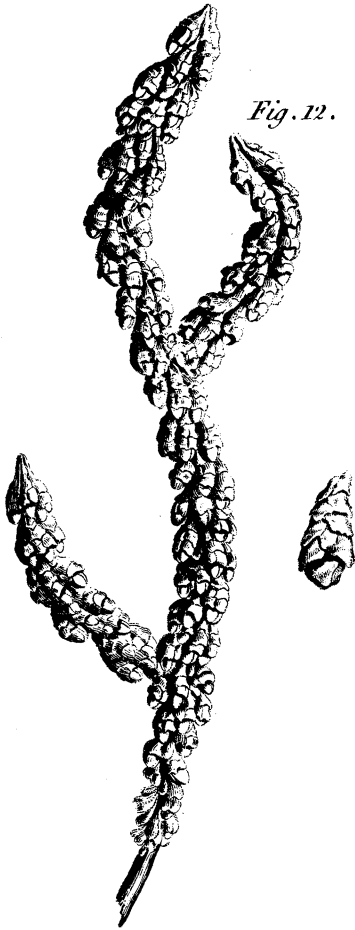
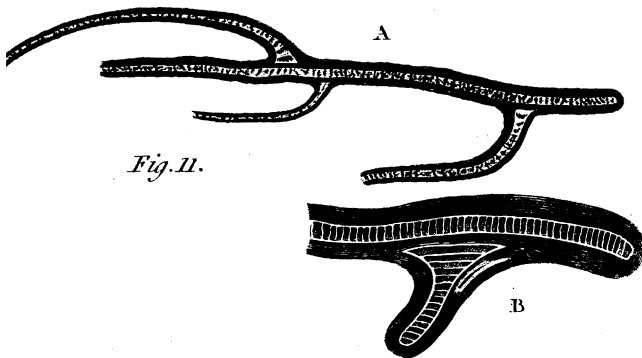


Fig. 11.



forth from thence their *polype* suckers in search of food; for drawing them in suddenly, and contracting the *sphincter* muscles of these starry cells, in order to secure these tender parts from danger; and likewise that there is, as we have already mentioned, proper secretory ducts, to furnish and deposit the *osseous* matter, for the supply of the bone, both of the stem and branches as well as the base, to secure its station with firmness, amidst the boisterous element where it is appointed to be. That there are *ovaries* in these animals is without doubt; for in most of those that were sent to me preserved in spirits, the eggs were very visible upon making longitudinal sections in the same manner and form as in the *alcyonium digitatum*, called *dead man's hand*, see Philosophical Transactions, vol. LIII. tab. xx. fig. 11. but much larger; and it is very probable, many of these animals are *viviparous*, as we have seen among the *fertulariæ*.

So that I must conclude, that though they grow in a branched form, they are no more allied to vegetables than they are to the ramified configurations of *sal ammoniac*; to the elegant branched figures in the Mocha and other Gems, called *dendrites*; to the *arbor Dianæ*, or the arboresecent figures of the Cornish native copper: consequently, that animal life doth not depend on bodies growing according to a certain external form. Hence it appears, that this metamorphosis of a plant to an animal is a flowery expression, and in my opinion, better suited to the poetical fancy of an OVID, than to that precise method of describing which we so much admire in a natural historian.

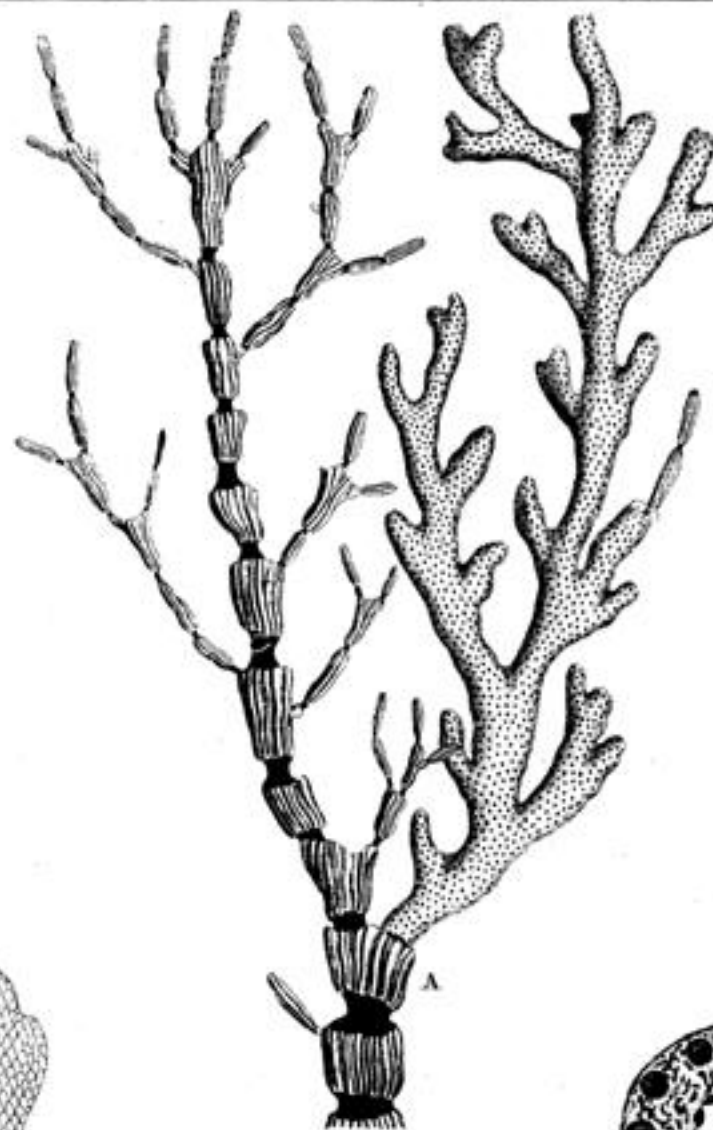
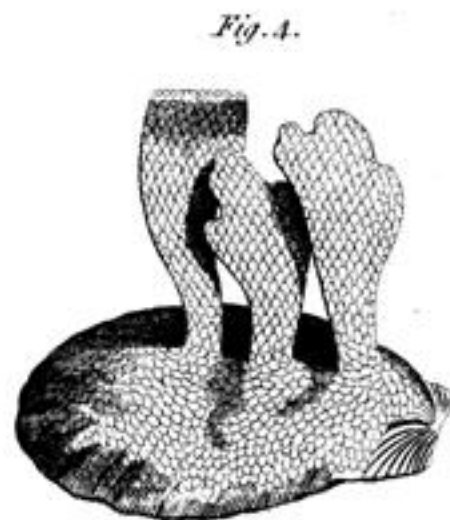
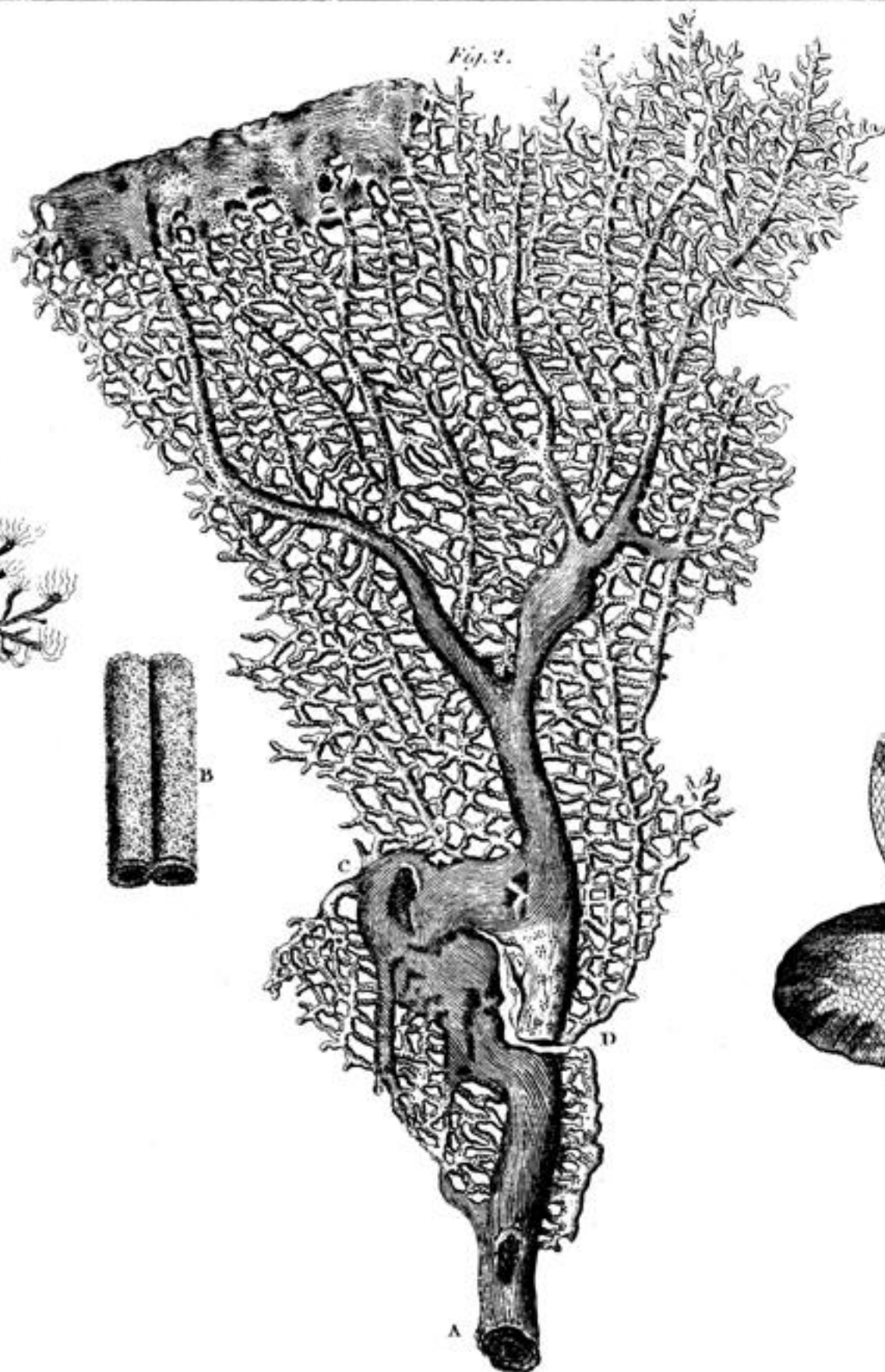
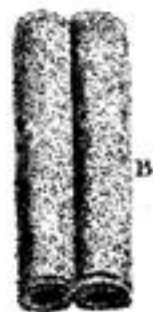


Fig. 3.

